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Introduction

This book is aimed for students and practitioners with a basic knowledge in computer networks. One possible source on the basics of computer networks is the book by Tanenbaum and Wetherall [1].

We will provide the reader with all concepts of currently used Internet Protocol (IP) technologies to deliver multimedia efficiently to the user. The book does not treat any non-IP multimedia technologies – for example, TV/Audio transmission by satellite, cable, or other terrestrial methods. For examples of these technologies, see Ref. [2].

We provide enough detail to understand the operation and transmission of multimedia data over a packet network. However, it is not intended to provide sufficient detail for an implementation of a complete multimedia application. For that level of detail, we provide links to the relevant standards and other literature.

The transport of multimedia over the network requires timely and errorless transmission much more strictly than any other data. The criticality of transport has led to specialized protocols and to special treatment within multimedia applications (telephone, IP-TV, streaming, and others) to overcome network issues.

The percentage of multimedia traffic over the Internet is already substantial today and, based on 2014 estimations, will grow to 79% of all traffic by 2018. Therefore, the knowledge of protocols used and handling of the traffic needs to increase as well.

The next chapter will exemplify the typical requirements of multimedia applications, and we will show their protocols and implementation in later chapters.

Before we treat the underlying network functions in Chapter 4 and synchronization in Chapter 5, we will treat coding and compression of multimedia in Chapter 3. At first glance, the need for the treatment of coding and compression may not be obvious, since in computer networking, one typically assumes that the lower layers are independent of the application layers. However, experienced networkers know that even data-driven applications occasionally show unacceptably long response times over Wide Area Networks (WANs). In such situations, network and application engineers jointly analyze this in network labs, and after that, the application and/or network gets changed. Multimedia applications require an absolutely optimal interworking with the network since it cannot afford response time variations of a second as a data-driven application. This optimization requires knowledge

Multimedia Networks: Protocols, Design, and Applications, First Edition. Hans W. Barz and Gregory A. Bassett.

of what options are possible on both sides. Consequently, we have to treat coding and compression for multimedia in Chapter 3.

While the next chapters handle technologies, we also have to understand how multimedia fit into existing network types, which standard organizations are creating the specifications, and how the market functions. These elements strongly influence the real use of multimedia.

1.1 Types of Networks

We will classify networks according to the following types: Internet, Telecommunication providers, Companies, Universities, and Home. It will become obvious that certain multimedia applications only work well in certain network types. Each network type is characterized by the following elements:

Administration: Organization of the administration
Redundancy/stability: Network is constructed to fulfill certain stability goals
Service quality: Availability of service classes guaranteeing traffic quality
Monitoring: Extent of network monitoring
Standards: Standards on which the network is based
Operator: Who operates the network.

1.1.1 Internet

The Internet has central bodies for standardization – Internet Engineering Task Force (IETF) – and addressing – Internet Corporation for Assigned Names and Numbers (ICANN). However, the Internet has no central administration that rules all interconnection and technical implementation details. The Internet offers a lot of redundancies, but there is no authority that plans this in detail. Service qualities do not exist and cannot be contracted. The network is monitored in parts but not as a whole.

The standards of the IETF govern all traffic and protocols. In some locations, additional protocols may work, but this is not true globally.

A plethora of telecommunication providers and institutions operate the Internet.

1.1.2 Telecommunication Provider Networks

Each telecommunication service provider (Telco) has a home territory where he owns cable infrastructure. Historically, each country has one major network provider who had once the monopoly for all telecommunication services within the country (incumbent). With the exception of the United States, the incumbents still own the majority of all cable infrastructure within their home country and typically all connections to the households. The particular situation in the United States slows the implementation of High-End TV as presented in Chapter 11.

Major Telcos contract network links or network capacity from other Telcos and build international cable infrastructure jointly in consortiums. The biggest Telcos of the world are American Telephone and Telegraph (AT&T, United States), Verizon (United States), British Telecom (BT, United Kingdom), Orange (France), German Telekom, Nippon Telegraph and Telephone Corporation (NTT, Japan), Telefonica (Spain), and Colt (United Kingdom).

Each Telco's network is centrally administered, and all redundancy is centrally planned. The network is monitored with the exception of links to the households. Service quality can also be provided at additional cost over contracted links in other countries. The Telcos offer services to their clients (companies, universities, end users, other providers) in different quality and throughput levels:

- Pure connectivity – that is, a link or part of a link with given throughput – based upon IEEE (International Electrical and Electronics Engineers) standards
- Data traffic based upon IETF standards
- Voice traffic based upon International Telecommunication Unit (ITU) standards.
- Television distribution based upon Digital Video Broadcast (DVB) or Advanced Television Systems Committee (ATSC) standards.

All major Telcos offer additional value-added services – for example, provide outsourcing services for companies.

The term Internet Service Provider (ISP) is used for those Telcos that provide Internet service. Mostly, all Telcos are also ISPs.

1.1.3 Company Networks

National and international companies own the networks in their premises – that is, data network equipment as well as telephone switches plus end-devices and cabling. One or multiple Telcos provide WAN connections; also tunnels over the Internet deliver the connectivity. The networks are centrally administered and monitored. All redundancy is well planned. Quality guarantees are possible if contracted from the Telcos plus internal management on LANs.

The networks use IETF, ITU, and diverse provider protocol standards. The connections to the Internet use firewalls plus Network Address Translation (NAT) and allow Virtual Private Networks (VPNs) connections to the company. Often, companies have dedicated links to other businesses to exchange well-controlled information.

All companies' networks tend to have a star-like topography with the headquarters at the center. This topology has consequences for some multimedia services – see Section 12.1.

1.1.4 University Networks

University networks are similar to company networks within one country. Of course, interconnections of university networks also exist. In contrast to business networks, interconnections to other parties are typically without controls. Since the main difference is security, we can see a university network as a company network, and we will not treat them specifically any further.

1.1.5 Home Networks

Home networks have a simple topology. Redundancy, quality, and monitoring generally do not exist in home networks. The quality of operation depends on the end customer and is usually of inferior quality. The network uses IETF and specific home network protocols; in Chapter 10,

Table 1.1 Characteristics of Network Types

	Internet	Telcos	Company	Home
Administration	Distributed	Central	Central	Central
Redundancy	Yes: not really planned	Yes: planned	Yes: planned	No
Quality	No	Possible	Possible	No
Monitoring	Partially	Yes	Yes	No
Standards	IETF	IETF and ITU	IETF & ITU and others	IETF plus Home protocols
Operator	Many	One	One	One, without knowhow

we will treat home network protocols. The diversity of end devices is significant in relation to the network size.

A home network is typically connected to the Internet via a Telco's DSL or cable router. In some cases, Telcos offer quality assurance in combination with additional services.

1.1.6 Overview

Table 1.1 summarizes the characteristics per type. In subsequent chapters, the reader will understand which multimedia application best operates in which network type. We summarize this in Section 12.5.

1.2 Standard Organizations

The ITU has investigated all committees in "Information and Communication Technology," and their report lists 227 organizations [3]. We will only mention the most important ones with respect to multimedia:

ITU: International Telecommunication Union – formerly Consultative Committee International Telecommunication Union (CCITT) – standardized all historical telephone standards. As well, numerous compression standards were created in the subgroup "Moving Picture Expert Group" (MPEG) and "Joint Photographic Experts Group" (JPEG). The MPEG group and the JPEG group are collaborations – Joint Telecommunication Committee (JTC) – between the ITU-Telecommunication (ITU-T) and ISO/IEC.
The International Standards Organization (ISO) and the International Electrical Committee (IEC) do not play a significant role in multimedia.

IETF: The Internet Engineering Taskforce (IETF) governs all Internet protocols; all publications are "Request for Comments" (RFC) and carry continuous numbers. An RFC has a status: Informational, Experimental, Proposed Draft, Draft Standard, Standard, and Historic; however, even Proposed Drafts and Draft Standards are often executed as being a Standard.

Some collaborations with other standard bodies exist. In Chapter 7, we will list a common standard with the ITU.

ETSI: European Telecommunication Standard Institute is the follow-up organization of Conférence Européenne des Administrations des Postes et des Télécommunications (CEPT). ETSI Standards are binding in the European Union but also used elsewhere. Asia and Latin America use, for example, ETSI mobile telephone standards.
ETSI publishes the standards of DVB as European Standards. One can compare ETSI with the Federal Communication Commission (FCC) in the United States.

DVB: Digital Video Broadcasting is a consortium of more than 270 companies, Telcos, and representatives from standard bodies. The consortium creates standards for the transmission of digital voice and video.

ATSC: Advanced Television Systems Committee is the US counterpart of the DVB.

W3C: The World Wide Web Consortium also defines multimedia standards when they are integrated with browsers.

DLNA: Digital Living Network Alliance is a consortium of more than 250 companies. DLNA set home network standards, which include Universal Plug and Play Forum (UPnP) protocols.

Others: Worthwhile to mention are audio standards by the Audio Engineering Society (AES), interoperability specifications by the Internet Multimedia Telecommunication Forum (IMTC), and home – Telco gateway specifications by the Home Gateway Initiative (HGI). Some others will be explained as and when they occur in the text.

1.3 Market

The market has many players, and we try to segment them, but since all of them try to enter other market segments, the classification might get blurred over time.

Computer software suppliers: Here, we see Microsoft, Google, and Apple delivering the so-called TV solutions (playing only movies in most countries), defining standards in contrast to standard committees, and offering streaming players. Microsoft, in addition, provides VoIP telephone/video server plus presence (Lync). Microsoft also produced software solutions for the operation of streaming service (Mediaroom) but sold this to Ericsson. Google with YouTube offers a public usable video streaming platform.
Their strategy has always been to maintain the user interface and hinder others to encroach on it.

Network hardware/software supplier: Most prominent here is Cisco, but there are, of course, also Nortel, Ericsson, Avaya, and Siemens. However, the most complete platform on IP multimedia products is Cisco with VoIP telephone server, high-end video conferencing, streaming platforms, cache engines, set-top boxes, digital signs, video surveillance, and media monitoring solutions. The other mentioned companies once produced non-VoIP telephone systems and grew from phones into this business. For videoconferencing, Polycom is also a mentionable provider.
Their strategy is to own the user interface within companies and to expand the network for better multimedia services.

Telcos and cable TV providers: There are a lot of them, and we cannot even try to provide a list but the biggest were mentioned before in Section 1.1.2. Apart from all connectivity services, they also offer telephone, TV distribution, and streaming services.

Their strategy is to maintain customers by bundling their services – for example, the so-called triple play (Internet connection, fixed and mobile telephone) or quadruple play by adding high-end Internet TV access. The bigger a provider is, the better bundles he can offer.

TV production studios: Again, there are a lot of them globally. In the past, they produced the TV program movies and contracted the transmission to Telcos and cable providers. Now, they themselves offer streaming platforms.

Streaming platforms: Of course, for movies, there are Netflix, Hulu, Amazon, and Google with YouTube. Also, the Telcos and cable TV providers have movie streaming platforms but often only accessible at their customers' homes. Some streaming providers started to produce movies similarly to the TV production studios or the movie industry.
Moreover, we also see many audio streaming platforms – for example, Spotify.